1. COMMENTS ON NOTICE OF PROPOSED RULES

This document provides comments to FAA NPRM Docket Number FAA-2003-14449.

The comments are made on the behalf of Winged Systems Corporation by Stuart W. Law, President. Winged Systems Corporation is a developer of SVS/EVS technology. Mr. Law is also a practicing FAA Systems and Equipment DER and has significant background in the evaluation of SVS and EVS technologies, including being a primary investigator in area of required EVS image quality during the FAA/USAF Synthetic Vision[1] Technology Demonstration Program (SVTDP).

Unless explicitly stated, references to EVS and SVS made in these comments describe systems which would conform to the FAA proposed definitions.

1.1 Limitation to EVS Technology is Wrong

The NPRM is couched in terms of a very limited definition of EVS technology and explicitly excludes the use of other technologies to obtain the same results.

This is contrary to long-established FAA policy of remaining technology neutral in rule making.

There is no current evidence that other technologies can or cannot achieve the same, or even better operational capabilities, availability, reliability, and integrity. The rules should not explicitly deny exploitation of other technologies, merely because the first (and only at this moment) to certify a product uses an EVS product.

Part 91 and other "Operating" rule making should focus on required operational capabilities and rely on Aircraft Certification to achieve those goals through whatever technology and innovation industry can present that provides the needed operational capability and requisite level of safety.

Discourages Technology, Innovation, and improved Flight Safety

There are inherrent advantages and disadvantages to both EVS and SVS technologies when applied to approach and landing operations. It is highly probable that mature low-visibility solutions will offer combinations of both technologies. As written, the rules would preclude or at least seriously discourage the future use of SVS technologies, even as a means to further enhance or validate the products of EVS technologies.

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[1] While named "Synthetic Vision Technology Demonstration", all of the technology used in that program would fit under the proposed FAA "EVS" definition.

As evidence of the desirable aspects of SVS only or combined SVS/EVS technologies, the following examples are offered:

- EVS unpredictably has a limited vision capability while SVS capability would be reliably available for much further distances (such as full scene capability from the Final Approach Fix), allowing for improved approach stability and lower crew workloads.
- EVS is currently using a raster (Television) display technology while SVS can be implemented in “Stroke” (line drawing) technology. Raster inherently obscures the entire view of the outside world through the HUD while Stroke has no obscuration at all except where the actual relevant material such as runway outlines are being displayed. The FAA/USAF SVTDP documented instances where the crew using HUD EVS were unable to see real visual cues due to the EVS raster obscuration of the visual runway view, forcing unnecessary Go-Arounds.
- EVS images in minimal weather will be limited to “improved eyesight” giving only a few (for instance) runway lights. A SVS enhanced solution would give complete approach lead-in as well as outline of the load bearing boundaries of the runway.
- At most runways in wet, icy, or snowy weather, EVS is unpredictably incapable of providing any indication of where the desired touchdown point is on the runway or the extent of the touchdown zone (typically extending from 500’ to 3000’ down the runway). SVS technology would be able to reliably provide both.

1.2 No Credit For EVS In Initiating An Approach

The NPRM does not provide any capability to *initiate* an approach (135.225 or 121.651) where EVS is already providing a view of the runway environment but weather reporting is below published approach minimums.

1.3 Inconsistent EVS Credit In Continuing An Approach

135 / 121 operations initiating an approach with no change to weather during the approach will rely on the conditions of their operations procedures for EVS credit, however if the weather changes after starting the final approach segment, the crew will rely on the proposed changes to 135.225 and 121.651. The changes to the Ops rules (135.225 and 121.651) should merely allow the carrier’s Operations Procedures to provide EVS credit instead of 91.175(l) for all variants of weather and its changes.

1.4 EVS Visual References Are Inappropriate

The list of "visual" references to be distinctly visible and identifiable to the pilot using the enhanced flight vision system includes:

91.175(l)(3)(ii) The runway threshold and the touchdown zone.

As I read the english, this means that the entire first 3000 feet of the runway must be in view. Depending upon the aircraft angle of attack and forward look angle, it may be difficult to see the runway threshold as the AATDZ approaches 100'.

1.5 Overly Complex Rule Change To Effect Simple Objective

Analysis of the NPRM shows that the net operational capability being granted for EVS use is only that portion from a published DA/DH/MDA down to 100' AATDZ.

It appears that the proposed NPRM is exceedingly complicated to effectively allow EVS to be counted as the equivalent of an Approach Lighting System under 91.175(c)(3)(i).

1.6 EVS Users Denied Accepted Visual References To Complete Landing

However, EVS pilots using 91.175(l) would be denied utilization (91.175(l)(4)) of many of the landing visual references which are available to 91.175(c)(3) pilots who are allowed descent to 100' AATDZ under either 91.175(c)(3)(i) or HUD / HGS type credits. No reason for denying these well proven visual references is justified in the prologue to the NPRM.

The visual references lost to EVS users for non-EVS operations below 100' AATDZ include:

- The physical threshold of the landing pavement (only lights or markings may be used)
- Runway end identifier lights
- Visual Approach Slope Indicator (which also provides an excellent reference for the nominal touchdown point)
- The touchdown zone to the extent that it can be determined beyond markings or lights.
- The runway or runway markings.
- The runway lights.

1.7 Dual Rule Coverage Is Not Conducive To Flight Safety

The NPRM requires that the pilot must deliberately choose which (91.175(c) or 91.175(l)) differing rule set he will conduct an approach. This imposes upon each GA or Commercial / Transport pilot the need to mentally maintain the differences between two highly similar rules on an approach by approach basis. No study I am aware of has shown that such a requirement is effective and would not increase the possibility of operational error.

The closest analogy I can find would be the changes between Cat I, II, and III approaches at the same runway. Here completely separate approach procedures are published and are required to be referenced during each approach.

Further, the rules do not specify if the pilot is free to switch between the requirements of the two differing rules during the approach to his best advantage or if he must choose a rule set before the approach and then stick with it regardless of the advantage to switching to the other rule set.

1.8 Determination of 100' AATDZ Is Not Adequate

The NPRM requires that non-EVS visual references be acquired before descending below 100' Altitude Above TouchDown Zone.

No criteria is given on acceptable means to determination this altitude.

Radar Altitude may be quite inappropriate since there are no controls on terrain prior to the runway threshold for non-precision approaches and non-appropriate controls for Cat I ILS. High terrain short of the field would result in excessive go-arounds while low terrain might result in dangerous or catastrophic results. It should be noted that Cat II / III rely on Radar Altitude to determine the DH, but that altitude is based upon detail survey's of the terrain short of the threshold. Such surveys are not common for non-precision and may not be adequately supported for Cat I approaches.

Barometric Altitude is subject to significant errors (some aircraft having errors >100') occurring due to changes in angle of attack or flap configuration that are commonly performed during the approach phase. When combined with basic altimetry errors which are also significant when when compared to 100', it is difficult to see how Barometric Altitude is to be the protecting measurement.

EVS as defined in the NPRM is totally incapable of determining the AATDZ. It should be noted that EVS is probably not even capable of measuring the descent angle to the nominal touchdown point.

It may be that the 100' criteria proposed by the rulemaking is not capable of being safely sensed by the flight crew for the non-precision and Cat I operations being considered.

1.9 Obstacle Avoidance Credit Given For EVS Is Incorrect

Many non-precision approaches are constructed such that the MDA and visibility charted provide the crew with the capability to see and avoid obstacles or obstructions in the possible paths descending from the MDA or from the terminating point of the approach.

Allowing EVS systems to be used in lieu of charted flight visibility may put the aircraft at serious risk since many obstructions or obstacles are not visible to EVS sensors and thus would not be displayed to a crew relying on EVS to transit the are below the MDA and 100' AATDZ. Even worse, the ability of EVS to see or not see many types of natural or cultural features is generally unpredictable to the flight crew.

Typical examples of this phenomena are:

- Radar based systems cannot image wood or wood products
- IR based systems are unable to image overlapping items at the same temperature, such as ice or snow covered objects against a ice or snow covered runway. This also occurs during the natural diurnal cycle during morning heating and evening cooldown. Depending upon each object's thermal characteristics, it may image or merge with the background at different times than other objects around it.

Cat I approaches are more favorably surveyed and may be possible.

1.10 Requirements for Touch Down Zone Are Not Possible At Most Runways

Proposed rules for 121 / 135 operators require (91.175(l)(1) that the "descent rate will allow touchdown to occur within the touchdown zone of the runway of intended landing;"

EVS as defined by the NPRM is not capable of allowing the crew to make this determination.

HUD – style inertial flight path vector symbology can be utilized to determine where current descent rates are taking the aircraft, but they require that the EVS sensor provide indications as to the beginning and end of the touchdown zone.

Category II and III runways have explicit paint markings and lighting of the touchdown zone, and thus could be used to satisfy this requirement assuming that the EVS sensor can continuously image one of them.

Category I runways have paint markings of the touchdown zone. These can be used if the EVS sensor can continuously image them with sufficient quality to determine the beginning and ending of the Touchdown zone (500' and 3000' nominally) marks from the threshold markers (especially on short runways having full marks on both ends). These paint marks may not be visible to many types of EVS sensors and not reliably visible to any EVS sensor.

Non-Precision Runways do not have any indication of a touchdown zone. Only a Threshold and Aim Point mark are provided. EVS is probably incapable of divining the extents of the touchdown zone at these runways.

1.11 Straight-In Approaches and EVS

The NPRM allows EVS to be used on all straight-in approaches. These are allowed to be up to ±30 degrees to the runway centerline. TERPs allows the angular intercept to be displaced from the threshold for Cat I approaches.

The vast majority of HUD visual system have only ±15 degrees of visual (30 degrees total) of display capability.

EVS as defined in the NPRM may not be capable of even imaging or displaying the runway environment of many "straight-in" approaches.

The NPRM does not indicate that any studies have been done to assure that EVS used in such environments would not lead the pilot to assume that the runway is in sight when in fact it is a taxiway which came into the field of view before the runway.

1.12 Differentiation Between Runway and Taxiway Environments

The NPRM does not require that a capability exist to differentiate a taxiway or other runway similar (e.g. lighted highway or drag-strip) environment from a runway environment.

EVS systems are usually incapable of distinguishing taxiway lighting or even taxiway environments from runway environments, especially when considering non-precision runways. Examples of these difficulties include:

- The sensor cannot determine the visual color of the lighting system
- For IR based systems, the radiated heat pattern is different than the visual light distribution (taxiway lights do not project light upwards at the same angle as runway lights
- Airports such as San Diego and LAX utilize a relatively uniform concrete surface over the entire operating area, making identification of runways and taxiways more difficult for many EVS sensor technologies.

These issues may become significant when there is a considerable altitude and thus distance between the MDA and the allowed 100' AATDZ, especially in non-precision approaches, especially when paired with the still limited look angles of modern HUD equipment.

1.13 Required Use Of HUD Not Justified

The FAA has long championed the use of HUD displays and has provided credit for their use. However, uses of technologies such as "raster EVS on HUDs" which are not qualified for touchdown and rollout operations may not be optimum, and may actually impede the safest landing operations.

HUD presentation and modern display symbologies including flight path vector, reference flight path angle, and horizon marks (and ideally airspeed error and trend) have been repeatedly shown to dramatically decrease workload and increase landing accuracy when overlaying the actual runway environment.

If the EVS raster image is substituted for the visual scene the following usually occur:

- The human ability to recognize the EVS raster scene requires substantial raster brightness in order to create at least 3 or 4 shades of grey in the image. Eight or more shades may be desirable for optimum resolution.
- Noise, most present in radar-based EVS technologies, but also possible in minimal temperature differential conditions with IR sensors tends to provide a minimal brightness over all of the HUD viewing area.
- The resulting raster brightness diminishes the ability of the pilot to resolve the visual runway image behind the raster.

EVS/HUD systems often provide bright raster for the initial pilot recognition of the sensor image and then reducing the raster to a minimal level for continued recognition of the already discovered scene while lowering the interference with the visual scene required at the 100' AATDZ point. This method has proven quite difficult to optimize for all possible human eye variations and for all the differing background scene brightness. At best it is a compromise for both EVS and visual recognition.

In environments where a transition to visual environments is required (such as this NPRM), a more optimum solution could be:

- Head down display of the HUD symbology overlaying rasterized EVS information
- Head Up display of the HUD symbology with the runway outline and touchdown zone information in stroked (line drawing) format, extracted from EVS and/or provided by SVS technologies.

Again, the operational requirement in terms of crew workload and ability to perform the landing to accuracy equal or better than established visual operations should be specified. It then is up to industry to demonstrate that their technologies provide that capability, whether by HUD, HDD or a combination of those or other novel display technologies in the aircraft certification process.

2. SUGGESTED ALTERNATIVE RULES

Given the contents of the NPRM prologue and my analysis of the rules, the following seems to accomplish the same operational objectives with significant reductions in operational complexity:

2.1 Definitions

Define EVS/SVS Capability:

"Any technology which normally results in the pilot having the equivalent of a visual scene which is equal or better than his actual visual scene. Primary elements of such a scene include:

- Real-Time presentation with total latencies below the level where pilot performance or man-in-the-loop control is impacted.
- Image presentation which is normally of sufficient quality to allow pilot recognition of useful visual features in approximately the same time frame as they would be recognized in a visual scene.
- A means to determine that the image components primarily used for approach and landing are indeed those of the intended runway. An acceptable means would be an image of sufficient quality that the pilot may positively assure its correctness.
- Combination of the image with symbology which results in the total pilot workload being equal or less to night visual operations with a VASI or PAPI at an runway suitable for the intended operation and with an accuracy equal to that stipulated for autoland in AC 120-28D."

2.2 Allow EVS/SVS to be used in lieu of an Approach Lighting System

Modify 91.175(c)(3)(i) by adding the following: An approved EVS/SVS system may be substituted for the approach light system when it is displaying:

- The approach light system (if installed); or
- The threshold or the lights or markings of the threshold and the lights or markings of the touchdown zone; or
- The touchdown zone or touchdown zone markings or touchdown zone lights; or
- The runway lights.

Modify 121.651(c)(3)(i) in a similar manner.

Modify 135.225 as in the NPRM except use 91.175(c)(3) as the reference. Or preferably, bring 135 up to the same text as 121.